

Applicant: Weinberg *et al.*
For: FLEXURAL PLATE WAVE SENSOR

1 1. A flexural plate wave sensor comprising:
2 a flexural plate having a length and a width; and
3 a comb pattern over the flexural plate with drive teeth disposed
4 across the entire length of the flexural plate to reduce the number of eigenmodes excited
5 in the plate and thereby simplifying the operation and design of the flexure plate wave
6 sensor.

1 2. The flexure plate wave sensor of claim 1 further including sense teeth
2 disposed across the entire length of the flexure plate interleaved with the drive teeth.

1 3. The flexure plate wave sensor of claim 2 in which the sense teeth face in
2 one direction and the drive teeth face in an opposite direction.

1 4. The flexure plate wave sensor of claim 1 wherein the comb pattern is
2 aligned with all the eigenmodes of the flexural plate thereby exciting one eigenmode in
3 the plate.

1 5. The flexure plate wave sensor of claim 1 wherein the comb pattern allows
2 the sensor to output a single pronounced peak thereby improving the performance of the
3 sensor.

1 6. The flexure plate wave sensor of claim 1 in which the comb pattern
2 reduces a transfer function of the sensor to a single peak, or a peak much larger than any
3 other peak.

1 7. The flexure plate wave sensor of claim 1 in which the drive teeth are
2 aligned with the eigenmodes excited in the flexural plate.

1 8. The flexure plate wave sensor of claim 2 in which the sense teeth are
2 aligned with the eigenmodes excited in the flexural plate.

1 9. The flexure plate wave sensor of claim 1 in which the comb pattern
2 provides for establishing electric fields which interact with piezoelectric properties of the
3 flexural plate to excite motion.

1 10. The flexure plate wave sensor of claim 1 in which the comb pattern is
2 made of copper.

1 11. The flexure plate wave sensor of claim 1 in which the comb pattern is
2 made of a material chosen from the group consisting of copper, titanium-platinum-gold
3 (TiPtAu) metal, titanium-platinum (TiPt) and aluminum.

1 12. The flexure plate wave sensor of claim 1 in which the comb pattern is
2 made of aluminum.

1 13. The flexure plate wave sensor of claim 1 in which the comb pattern is
2 approximately 0.1 μm thick.

1 14. The flexure plate wave sensor of claim 1 in which the comb pattern
2 includes wire bond pad areas and ground contacts.

1 15. The flexure plate wave sensor of claim 1 in which the drive teeth are on
2 the flexural plate.

1 16. The flexure plate wave sensor of claim 2 in which the sense teeth are on
2 the flexural plate.

1 17. The flexure plate wave sensor of claim 1 in which the drive teeth span
2 across an entirety of the width of the flexural plate.

1 18. The flexure plate wave sensor of claim 2 in which the sense teeth span
2 across an entirety of the width of the flexural plate.

1 19. The flexure plate wave sensor of claim 1 further including a base
2 substrate, an etch stop layer disposed over said base substrate, a membrane layer disposed
3 over said etch stop layer, a cavity disposed in said base substrate and said etch stop layer,
4 thereby exposing a portion of said membrane layer, said cavity having substantially
5 parallel interior walls, a piezoelectric layer disposed over said membrane layer and said

6 comb pattern disposed over said piezoelectric layer.

1 20. The flexure plate wave sensor of claim 19 wherein said piezoelectric layer
2 is formed from a material selected from the group consisting of aluminum nitrite, zinc
3 oxide and lead zirconium titanate.

1 21. The flexure plate wave sensor of claim 19 wherein said etch stop layer is
2 formed from silicon dioxide.

1 22. The flexure plate wave sensor of claim 19 wherein said membrane layer is
2 formed from silicon.

1 23. The flexure plate wave sensor of claim 19 wherein said base substrate is
2 formed from silicon.

1 24. The flexure plate wave sensor of claim 23 wherein base substrate includes
2 a silicon-on-insulator (SOI) wafer.

1 25. The flexure plate wave sensor of claim 24 in which the silicon-on-
2 insulator wafer includes an upper surface of epitaxial silicon forming the membrane layer
3 bonded to an etch stop layer.

1 26. The flexure plate wave sensor of claim 25 wherein the piezoelectric

2 transducer is deposited over the upper surface of the epitaxial silicon.

1 27. The flexure plate wave sensor of claim 25 wherein grounding contacts to
2 the epitaxial silicon are provided by etching an opening into the piezoelectric transducer.

1 28. The flexure plate wave sensor of claim 27 wherein the comb pattern
2 comprises titanium-platinum-gold (TiPtAu) metal, said comb pattern including
3 interdigital metal electrodes, wire bond pad areas, and ground contacts.

1 29. The flexure plate wave sensor of claim 24 wherein said base substrate is
2 approximately 380 μm thick.

1 30. The flexure plate wave sensor of claim 25 wherein said upper epitaxial
2 surface is approximately 2 μm thick.

1 31. The flexure plate wave sensor of claim 25 wherein said layer of SiO_2 is
2 approximately 1 μm thick.

1 32. The flexure plate wave sensor of claim 28 wherein said comb pattern is
2 approximately 0.1 μm thick.

1 33. The flexure plate wave sensor of claim 1 wherein the drive teeth are
2 approximately 300 to 2000 μm in length and the spacing between the drive teeth is

3 approximately 25 to 50 μm .

1 34. The flexure plate wave sensor of claim 1 wherein the sense teeth are
2 approximately 300 to 2000 μm in length and the spacing between the sense teeth is
3 approximately 25 to 50 μm .

1 35. A flexural plate wave sensor comprising:
2 a flexural plate having a length and a width; and
3 a comb pattern over the flexural plate with drive and sense teeth
4 disposed across the entire length of the flexural plate to reduce the number of eigenmodes
5 excited in the plate and thereby simplifying the operation and design of the flexure plate
6 wave sensor.

1 36. A flexural plate wave sensor comprising:
2 a flexural plate having a length and a width; and
3 a comb pattern over the flexural plate with first and second sets of
4 drive teeth disposed across the entire length of the flexural plate to reduce the number of
5 eigenmodes excited in the plate and thereby simplify the operation and design of the
6 flexural plate wave sensor.

1 37. The flexural plate wave sensor of claim 36 further including first and
2 second sets of sense teeth disposed across the entire length of the flexural plate.

1 38. The flexural plate wave sensor of claim 36 in which the first and second
2 sets of drive teeth face in opposite directions.

1 39. The flexural plate wave sensor of claim 36 in which the first and second
2 sets of sense teeth face in opposite directions.

1 40. The flexural plate wave sensor of claim 38 in which the first and second
2 sets of drive teeth are interleaved.

1 41. The flexural plate wave sensor of claim 39 in which the first and second
2 sets of sense teeth are interleaved.

1 42. The flexural plate wave sensor of claim 40 in which the first and second

2 sets of interleaved drive teeth span approximately fifty percent of the width of the flexural
3 plate.

1 43. The flexural plate wave sensor of claim 41 in which the first and second
2 sets of interleaved sense teeth span approximately fifty percent of the width of the
3 flexural plate.

1 44. The flexural plate wave sensor of claim 36 in which the first and second
2 sets of drive teeth face in the same direction.

1 45. The flexural plate wave sensor of claim 37 in which the first and second
2 sets of sense teeth face in the same direction.

1 46. The flexural plate wave sensor of claim 45 in which the first set of drive
2 teeth is interleaved with the first set of sense teeth.

1 47. The flexural plate wave sensor of claim 46 in which the first set of drive
2 teeth interleaved with the second set of sense teeth together span approximately fifty
3 percent of the width of the flexural plate.

1 48. The flexural plate wave sensor of claim 45 in which the second set of drive
2 teeth is interleaved with the second set of sense teeth.

1 49. The flexural plate wave sensor of claim 48 in which the second set of drive
2 teeth interleaved with the first set of sense teeth together span approximately fifty percent
3 of the width of the flexural wave plate.

1 50. A flexural wave plate sensor comprising:
2 a flexural plate having a length and a width; and
3 a comb pattern over the flexural plate with first and second sets of
4 drive teeth disposed over the flexural plate, the first set of drive teeth spanning
5 approximately seventy-five percent of the length of the flexural plate and the second set
6 of drive teeth spanning approximately twenty-five percent of the length of the flexural
7 plate, the comb pattern for reducing the number of eigenmodes excited in the plate and
8 thereby simplifying the operation and design of the flexural plate wave sensor.

1 51. The flexural plate wave sensor of claim 50 further including first and
2 second sets of sense teeth disposed over the flexural plate, the first set of sense teeth
3 spanning approximately seventy-five percent of the length of the flexural plate and the
4 second set of sense teeth spanning approximately twenty-five percent of the length of
5 the flexural plate, the first and second sets of sense teeth interleaved with the first and
6 second sets of drive teeth.

1 52. The flexural plate wave sensor of claim 50 in which the first and second
2 sets of drive teeth face one direction and the first and second sense teeth face in an
3 opposite direction.

1 53. A flexural plate wave sensor comprising:
2 a flexural plate having a length, width, and a center; and
3 a comb pattern over the flexural plate with first and second sets of
4 drive teeth disposed across approximately fifty percent of the length of the flexural plate,
5 each said set of drive teeth spanning approximately an entirety of the width of the flexural
6 plate at one end and curving toward the center of the flexural plate at approximately the
7 center of the plate, the comb pattern for reducing the number of eigenmodes excited in
8 the plate and thereby simplifying the operation and design of the flexural plate wave
9 sensor.

1 54. The flexural plate wave sensor of claim 53 further including first and
2 second sets of sense teeth disposed across approximately fifty percent of the length of the
3 flexural plate, each said set of sense teeth spanning approximately an entirety of the width
4 of the flexural plate at one end and curving toward the center of the flexural plate at
5 approximately the center of the plate.

1 55. A flexural wave plate sensor comprising:
2 a flexural plate having a length and a width; and
3 a comb pattern over the flexural plate, the comb pattern including drive
4 teeth and sense teeth, the drive teeth and the sense teeth disposed over the flexural plate,
5 the drive teeth spanning approximately fifty percent of the length of the flexural plate, the
6 sense teeth spanning approximately fifty percent of the length of the flexural plate, the
7 comb pattern for reducing the number of eigenmodes excited in the plate and thereby
8 simplifying the operation and design of the flexural plate wave sensor.

1 56. A flexural wave plate sensor comprising:
2 a flexural plate having a length and a width; and
3 a comb pattern over the flexural plate, the comb pattern including a set of
4 drive teeth and a set of sense teeth, the set of drive teeth and the set of sense teeth
5 disposed over the flexural plate, the set of drive teeth spanning approximately fifty
6 percent of the length of the flexural plate, the set of sense teeth spanning approximately
7 fifty percent of the length of the flexural plate, the comb pattern for reducing the number
8 of eigenmodes excited in the plate and thereby simplifying the operation and design of the
9 flexural plate wave sensor.

1 57. A method for manufacturing a flexural plate wave sensor, the method
2 comprising the steps of:
3 depositing an etch-stop layer over a substrate;
4 depositing a membrane layer over said etch stop layer;
5 depositing a piezoelectric layer over said membrane layer;
6 forming a comb pattern with drive teeth which span across an
7 entire length of the piezoelectric layer on said piezoelectric layer;
8 etching a cavity through the substrate, the cavity having
9 substantially parallel interior walls; and
10 removing a portion of the etch stop layer between the cavity and
11 the membrane layer to expose a portion of the membrane layer.

1 58. The method of claim 57 further comprising the steps of etching a hole in
2 the piezoelectric and forming a ground contact on the silicon membrane layer.

1 59. A method for manufacturing a flexural plate wave sensor, the method
2 comprising the steps of:
3 depositing an etch-stop layer over a substrate;
4 depositing a membrane layer over said etch stop layer;
5 depositing a piezoelectric layer over said membrane layer;
6 forming a comb pattern on said piezoelectric layer, said comb
7 pattern including drive and sense teeth which span an entire length of the membrane
8 layer;
9 forming a second transducer on said piezoelectric layer, spaced
10 from said first transducer;
11 etching a cavity through the substrate, the cavity having
12 substantially parallel interior walls;
13 removing the portion of the etch stop layer between the cavity and
14 the membrane layer to expose a portion of the membrane layer; and
15 depositing an absorptive coating on the exposed portion of the
16 membrane layer.

1 60. The method of claim 59 further comprising the steps of etching a hole in
2 the piezoelectric and forming a ground contact on the silicon membrane layer.